



# UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.

684.2925

First Named Inventor or Application Identifier

HIDEKI INA, ET AL.

Express Mail Label No.

## APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

## ADDRESS TO:

Assistant Commissioner for Patents  
Box Patent Application  
Washington, DC 20231

1. ☒ Fee Transmittal Form  
(Submit an original, and a duplicate for fee processing)
2. ☒ Specification Total Pages **35**
3. ☒ Drawing(s) (35 USC 113) Total Sheets **8**
4. ☒ Oath or Declaration Total Pages **2**
- a. ☐ Newly executed (original or copy)
- b. ☒ Unexecuted for information purposes
- c. ☐ Copy from a prior application (37 CFR 1.63(d))  
(for continuation/divisional with Box 17 completed)  
[Note Box 5 below]
- i. ☐ **DELETION OF INVENTOR(S)**  
Signed Statement attached deleting  
inventor(s) named in the prior application, see  
37 CFR 1.63(d)(2) and 1.33(b).
5. ☐ Incorporation By Reference (useable if Box 4c is checked)  
The entire disclosure of the prior application, from which a copy of  
the oath or declaration is supplied under Box 4c, is considered as  
being part of the disclosure of the accompanying application and is  
hereby incorporated by reference therein.

6. ☐ Microfiche Computer Program (Appendix)
7. Nucleotide and/or Amino Acid Sequence Submission  
(if applicable, all necessary)
- a. ☐ Computer Readable Copy
- b. ☐ Paper Copy (identical to computer copy)
- c. ☐ Statement verifying identity of above copies

## ACCOMPANYING APPLICATION PARTS

8. ☐ Assignment Papers (cover sheet & document(s))
9. ☐ 37 CFR 3.73(b) Statement (when there is an assignee) ☐ Power of Attorney
10. ☐ English Translation Document (if applicable)
11. ☐ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
12. ☐ Preliminary Amendment
13. ☒ Return Receipt Postcard (MPEP 503)  
(Should be specifically itemized)
14. ☐ Small Entity ☐ Statement filed in prior application  
Statement(s) Status full proper and desired
15. ☐ Certified Copy of Priority Document(s)  
(if foreign priority is claimed)
16. ☐ Other: \_\_\_\_\_

17. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:

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CLAIMS	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
	TOTAL CLAIMS (37 CFR 1.16(c))	11-20 =	0	X \$ 18.00 =	\$ 0.00
	INDEPENDENT CLAIMS (37 cfr 1.16(b))	6-3 =	3	X \$ 78.00 =	\$ 234.00
	MULTIPLE DEPENDENT CLAIMS (if applicable) (37 CFR 1.16(d))			\$ 260.00 =	\$ 0.00
				BASIC FEE (37 CFR 1.16(a))	\$ 760.00
			Total of above Calculations =		\$ 994.00
	Reduction by 50% for filing by small entity (Note 37 CFR 1.9, 1.27, 1.28).				
	TOTAL =				\$ 994.00

## 19. Small entity status

- a. ☐ A Small entity statement is enclosed
- b. ☐ A small entity statement was filed in the prior nonprovisional application and such status is still proper and desired.
- c. ☐ Is no longer claimed.

20. ☒ A check in the amount of \$ 994.00 to cover the filing fee is enclosed.

21. ☐ A check in the amount of \$ \_\_\_\_\_ to cover the recordal fee is enclosed.

22. The Commissioner is hereby authorized to credit overpayments or charge the following fees to Deposit Account No. 06-1205:

- a. ☒ Fees required under 37 CFR 1.16.
- b. ☐ Fees required under 37 CFR 1.17.
- c. ☐ Fees required under 37 CFR 1.18.

## SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

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SIGNATURE

*Steven E. Warner*

DATE

October 28, 1999

SEW/lmj

POSITION DETECTING SYSTEM AND  
EXPOSURE APPARATUS USING THE SAME

FIELD OF THE INVENTION AND RELATED ART

5           This invention relates to a position  
detecting system and an exposure apparatus using the  
same. The present invention is particularly suitably  
usable in a step-and-repeat type or step-and-scan type  
exposure apparatus (projection exposure apparatus),  
10   for example, for manufacture of various devices such  
as a semiconductor device (e.g., IC or LSI), and image  
pickup device (e.g., CCD), or a display device such as  
a liquid crystal panel, for example. More  
specifically, when a fine electronic circuit pattern  
15   formed on the surface of a first object such as a  
reticle is to be transferred by exposure or printed by  
projection through a projection optical system, to a  
second object such as a wafer in such exposure  
apparatus, the invention may be used in detecting  
20   positional relation related to a mark provided on the  
wafer, on the basis of optical interference.

          Projection exposure apparatuses for  
semiconductor manufacture should have a good  
performance for projecting and transferring a circuit  
pattern of a reticle upon the surface of a wafer at a  
25   high resolving power. The resolution for circuit  
pattern projection may be improved by enlarging the

numerical aperture (NA) of a projection optical system while holding the wavelength of exposure light fixed. Alternatively, it may be improved by using a shorter wavelength of light, for example, using i-line in place of g-line or using short-wavelength light such as a wavelength 248 nm or 193 nm as can be emitted from an excimer laser, for example, or light of synchrotron orbital radiation (SOR).

On the other hand, because of further miniaturization of a circuit pattern, it is required to align a reticle, having such electronic circuit pattern, and a wafer very precisely.

The required precision may be one-third or less of a circuit pattern. For a 1 giga-bit DRAM, for example, if a circuit pattern is based on a 0.18 micron rule, an overlay precision (alignment through the whole exposure region) of 60 nm or smaller may be required.

Furthermore, an overlay inspection system for measuring the overlay precision should have a precision of about 1/10 of the overlay precision. Thus, for a 1 giga-bit DRAM, a precision of 6 nm or smaller may be required.

As an attempt to accomplishing high-precision position measurement, there has been proposed a TIS correction method effective to reduce the influence of a TIS (Tool Induced Shift) which is a detection system

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based error factor among various measurement error factors.

Figure 1A illustrates the TIS correction. In this case, as an example of a position detecting pattern, a surface step (level difference) is defined on a silicon wafer 91 through an etching process, whereby a pattern 92 is produced. After completion of an alignment operation, the relative positional relationship between this pattern 92 and a resist image pattern 93, having been printed and developed, is measured. The measurement is made twice, in the TIS correction method. Here, the second time measurement is performed by rotating the wafer 91 by 180 deg. as compared with the first time measurement. For this reason, the first time measured value is called a zero-deg. measured value  $\Delta_{0\text{-deg}}$ , while the second time measured value is called a 180-deg. measured value  $\Delta_{180\text{-deg}}$ .

In accordance with the TIS correction method, a value obtainable by subtracting a 180-deg. measured value  $\Delta_{180\text{-deg}}$  from a zero-deg. measured value  $\Delta_{0\text{-deg}}$  and then by dividing the difference by 2, is used as a measured value  $\Delta_{\text{TIS correction}}$ . Here, a value which is obtainable by adding the zero-deg. measured value  $\Delta_{0\text{-deg}}$  and the 180-deg. measured value  $\Delta_{180\text{-deg}}$  and then by dividing the sum by 2, is called a TIS.

Most of currently used registration

inspecting systems and alignment detecting systems are based on a bright-field image processing method.

Figure 1B is a schematic view of a main portion of a registration inspecting system (position detecting

system) of known type. In this example, a special mark is provided on a wafer. The position detection is performed by producing, through an optical system, an image of that mark on an image pickup device such as a CCD, for example, and by making various signal processing to an electric signal resulting from that image.

More specifically, a mark 2 is produced on a wafer 1 through an etching process, for example. Also, a mark 3 is formed upon that mark 2 through a lithographic process. The registration inspecting system operates to measure the relative positional relation between these marks 2 and 3. A light beam 6 emitted from a halogen lamp 5 is directed through an optical filter 5a and a lens 5b and via a mirror 5c to a fiber 7. The light from the fiber 7 is directed through an illumination system 8, and a polarization beam splitter 9 reflects S-polarized light. The light goes via a relay 12, a mirror 4, a quarter waveplate 10 and an objective lens 11, and it illuminates the two marks 2 and 3 on the wafer 1. The illumination system comprises a lens 8a for collecting light rays from the fiber 7, a stop 8b, a lens 8c for collecting

light from the stop 8b, and a mirror 8d.

Reflected light from the two marks 2 and 3 goes back along the path of illumination, and it goes via the objective lens 11, the quarter waveplate 10, the mirror 4 and the relay 12. Since the polarization direction is P-polarized, at this time, the light passes through the polarization beam splitter 9. The light goes via a quarter waveplate 21, and it is directed through an erector 13 to the image pickup surface of a CCD camera 14, whereby images of the two marks 2 and 3 are formed thereon. The images of the two marks 2 and 3 are transformed by the CCD camera 14 into electric signals which are then applied to a computer (computing means) 15. The signals are processed and analyzed by the computer 15, whereby the relative positional relationship between the two marks 2 and 3 is detected.

The imaging performance most required in this optical system is the symmetry of image (mark image). If there is anything that deteriorates the image symmetry in the optical system, a TIS is there.

In this type of detecting systems, the magnification is made high such as 100x, for example, and, in most cases, a region close to the optical axis is used. Thus, the main factors which cause deterioration of the image symmetry are not abaxial aberrations but, rather, they are an eccentric comma

In order to meet further increases in the integration density of a semiconductor device, a three-dimensional arrangement of the device structure has been attempted in addition to further miniaturization of the circuit pattern. If the numerical aperture of a projection optical system is enlarged for attaining a higher integration density of a semiconductor device, the depth of focus of the projection optical system is shortened. For this reason, it is very important to polish the surface of a semiconductor device to remove any surface level differences or surface irregularities to improve the flatness, to ensure that a photoresist is applied to a flattened surface to thereby accomplish higher resolution of projection exposure.

Also, polishing an insulative film layer to be provided on a silicon substrate, to assure a uniform thickness film layer thereon is an important factor for uniforming capacity dispersion of among different layers or regulating the "Via Hole" depth.

A chemical mechanical polishing (CMP) method  
25 is an example of a flattening method for assuring  
flatness by removing any surface level differences or  
surface irregularities of a semiconductor device.



This flattening method however involves a serious problem in regard to a mark to be used for the detection, since the surface level difference of that mark is also removed by the flattening operation.

Therefore, in the dark-field image processing which is used most frequently and with a good precision, for example, the contrast of a mark image used in the measurement becomes very low, causing degradation of the detection precision.

There is a phase difference detecting method, as another example. Since, however, a phase plate should be inserted into an optical system, in this method, it may cause a TIS described hereinbefore. While the contrast may increase, the precision is difficult to achieve. Particularly, in order that the system may be used in combination with an ordinary bright-field system, a phase plate has to be demountably mounted into the optical system. This is a large factor for production of TIS.

#### SUMMARY OF THE INVENTION

It is accordingly an object of the present invention to provide a position detecting system by which, like a phase difference detecting method, a higher contrast is assured while a TIS causal factor is held small, and by which a position detecting mark can be detected stably and with a good precision even

in a process of low surface-level difference such as a CMP process, for example, such that a pattern of a reticle can be transferred to a wafer with a good precision.

5           It is another object of the present invention to provide an exposure apparatus having such position detecting system.

          These and other objects, features and advantages of the present invention will become more  
10   apparent upon a consideration of the following description of the preferred embodiments of the present invention taken in conjunction with the accompanying drawings.

15   BRIEF DESCRIPTION OF THE DRAWINGS

          Figure 1A is a schematic view for explaining a TIS correction method.

          Figure 1B a schematic view of an optical arrangement of a registration inspecting system of  
20   known type.

          Figure 2 is a schematic view of a position detecting system according to a first embodiment of the present invention.

          Figure 3A is a schematic view for explaining  
25   an example of focus under a condition of an interference image that the outside of a mark is bright.

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Figure 3B is a schematic view for explaining an example of focus under a condition of an interference image that the outside of a mark is dark.

Figure 4 is a schematic view for explaining signals corresponding to the conditions of interference images that the outside of the mark is bright and that the outside of the mark is dark, as well as a signal corresponding to the difference between these signals.

Figure 5 is a schematic view for explaining the principle of a Linnik interference microscope system.

Figure 6 is a schematic view for explaining the principle of a Mirau interference microscope system.

Figure 7 is a schematic view of a position detecting system according to a second embodiment of the present invention.

Figure 8 is a flow chart of device manufacturing processes, in an embodiment of the present invention.

Figure 9 is a flow chart for explaining details of a wafer process in the procedure of Figure 8.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 2 is a schematic view of a main

portion of a first embodiment of the present invention. In this embodiment, the invention is applied to a registration inspecting system which is incorporated into a step-and-repeat type or step-and-scan type projection exposure apparatus for use in manufacture of semiconductor devices or any other microdevices. While the following description will be made on an example of inspection of registration between two marks, the system may be used as an alignment detecting system for detecting a position of an alignment mark or as a wafer alignment system.

The position detecting system illustrated is arranged so that two alignment marks 2 and 3, each being formed on a wafer 1 with a three-dimensional shape, are illuminated with non-sensitizing light (non-exposure light) such as light from a He-Ne laser (light source) 31, for example, of a wavelength 633 nm with which a photoresist applied to the wafer 1 is not sensitized, wherein the light from the light source is projected through various components to be described later.

Light from these marks 2 and 3 is directed through various components (to be described later) and to a CCD camera 14, such that the positional information on the alignment marks 2 and 3 is observed through the CCD camera 14, on the basis of which the positions of the marks are detected.

On the other hand, in this embodiment, a reticle (first object: not shown in the drawing) having a circuit pattern formed thereon is illuminated with light (exposure light) from a light source which is a component of an illumination system (not shown) of a projection exposure apparatus, such as, for example, light of g-line or i-line from an ultra-high pressure Hg lamp or exposure light of an emission wavelength from an excimer laser. The projection optical system (not shown) serves to project the circuit pattern of the reticle onto the surface of a wafer (second object) 1 with a reduction magnification of 1:5 or 1:10, for example.

The wafer 1 is placed on a wafer chuck, not shown. The wafer chuck is mounted on a  $\theta$ -Z stage (driving means: not shown), and it serves to attract the wafer 1 onto its chucking surface so that the position of the wafer 1 does not shift against any vibrations. The  $\theta$ -Z stage is mounted on a tilt stage (not shown), and it serves to move the wafer 1 in a focus direction (a direction of an optical axis of the optical system), upwardly and downwardly.

In the position detecting system shown in Figure 2, an etching pattern mark (mark) 2 is formed on a silicon etching wafer (wafer) 1 through a lithographic process, a development process and an etching process, for example. On the thus provided

etching pattern mark 2, a resist pattern mark (mark) 3 is formed through a lithographic process and a development process. In the system shown in this drawing, the relative positional relation between these two marks 2 and 3 is measured.

In the measuring system of this embodiment, a mark provided on a wafer is imaged upon a photoelectric converting element through an optical system, and the position of the wafer is measured on the basis of a corresponding video signal. Here, coherent light is used as a light source, and a rotary diffusion plate is disposed between the light source and a fiber to transform the light into incoherent light. The mark on the wafer is illuminated with the incoherent light. A portion of the illumination light is reflected at a plane which is optically conjugate with the mark on the wafer, and it is re-combined with the reflection light from the mark of the wafer. These lights as re-combined are imaged upon the photoelectric converting element to form an image thereon. As an image to be practically used in the measurement, an image which is obtainable by subtracting, from an image at a focus with which the difference in reflection factor between the outside and the inside of the mark on the wafer becomes largest, an image at a focus with which the difference in reflection factor becomes similarly largest but the

5                   Next, the registration inspecting method  
(mark position detecting method) in this embodiment,  
will be described. This may be applied to detection  
of an alignment mark position in an ordinary alignment  
process.

Denoted at 33 is a condenser lens for  
20 collecting light (incoherent light) from the rotary  
diffusion plate 32. The light is then reflected by a  
mirror 6, and it enters a fiber 7. The light emitted  
from the fiber 7 is collected within an illumination  
system 8, wherein S-polarized light is reflected by a  
25 polarization beam splitter 9 and is then imaged at a  
point  $F_2$ . Thereafter, the light goes via a relay  
optical system 12, a mirror 4, a quarter waveplate 10

and an objective lens (projection optical system) 11, in this order, and it illuminates two marks 2 and 3 formed on the wafer 1 surface. The illumination system 8 comprises a lens 8a, a stop 8b, a condenser lens 8c and a mirror 8d. The stop 8b and the point  $P_2$  are placed optically conjugate with each other.

The reflection light from the marks 2 and 3 on the wafer 1 goes back along its on-coming path, via the objective lens 11, the quarter waveplate 10, the mirror 4 and the relay optical system 12, in this order. It is then imaged at the point  $P_2$  and, thereafter, it enters the polarization beam splitter 9. Since the light impinging on the polarization beam splitter 9 is P-polarized light, it passes through the beam splitter 9. Thereafter, it passes through a quarter waveplate 21 and an erector 13 by which it is directed to an image pickup surface of a CCD camera 14. By this, images (mark images) of the two marks 2 and 3 are formed on the image pickup surface.

Next, a reference light for producing an interference image on the basis of the image of the marks 2 and 3 upon the image pickup surface of the CCD camera 14, will be explained.

The P-polarized light passed through the polarization beam splitter, which is of the light from the light source 31 and passed through the illumination system 8, is transformed by a quarter



wafeplate 22 into circularly polarized light which is then reflected by a mirror 23. Here, the position of the mirror 23 is placed on a plane which is optically conjugate with the wafer 1 to be observed. The

5 reflected light goes again through the quarter waveplate 22 by which it is transformed into S-polarized light and enters the polarization beam splitter 9. The light which is S-polarized light is reflected by the polarization beam splitter 9.

10 Thereafter, it passes through the quarter waveplate 21 and the erector 13, by which it is projected on the image pickup surface of the CCD camera 14, as a reference light. Thus, upon the image pickup surface of the CCD camera 14, the reference light is  
15 superposed on the reflection image from the mark 2 or 3 of the wafer 1, whereby an interference image is produced thereon.

The images of the two marks 2 and 3 are photoelectrically converted by the CCD camera 14 into  
20 corresponding signals which are applied to a computer (computing means) 15. The signals are processed by the computer 15, whereby the relative positional relationship between the marks 2 and 3 is detected.

In the present embodiment, an interference  
25 image related to the marks 2 and 3 is produced in the manner described above. Thus, in this embodiment, an image of higher contrast than an image obtainable with

ordinary bright-field illumination, can be produced.  
Further, in this embodiment, a difference between  
interference images corresponding to two focuses may  
be taken, by which an image of twice contrast can be  
5 produced.

More specifically, these two focuses may be  
set as those focus positions where, as shown in  
Figures 3A, 3B and 4, the difference between an output  
of the CCD camera 14 corresponding to an alignment  
10 mark 41 (which corresponds to the top face 2a of the  
mark 2 of Figure 2) and an output of the CCD camera  
corresponding to a mark 42 outside the mark 41 (which  
mark 42 corresponds to the bottom face 2b of the mark  
2 of Figure 2), that is, the difference in image  
15 intensities of them, becomes largest and also where  
their signs are opposite to each other. The positions  
can be determined on the basis of the intensity of  
reflection light from the mark 41 or 42 as the wafer 1  
is moved along the optical axis direction of the  
20 optical system.

As an example, it is now assumed that the  
surface level difference of the alignment mark 41 is  
equal to  $\lambda/4$  which corresponds to  $1/4$  of the  
illumination wavelength  $\lambda$  (633 nm where He-Ne laser is  
25 used). Then, the intensity of the interference image  
of the mark 42 outside the mark 41 becomes highest as  
the focus is changed and set to a bright interference

ORIGINAL DOCUMENT

condition wherein the optical path difference between the reference light and the mark 42 outside the mark 41 is equal to a product of the illumination wavelength  $\lambda$  by an integer.

5           As regards the alignment mark 41, on the other hand, since the surface level difference is  $\lambda/4$ , the intensity becomes lowest, to the contrary (that is, if the reflection intensity of the reference light is equal to the reflection intensity from the wafer, the visibility of the interference fringe becomes  
10           higher, and the intensity disappears completely). As a result, a pattern (first image) such as shown in Figure 3A is produced.

          Second, if the focus is changed by  $\lambda/4$  from  
15           the initial focus, as shown in Figure 3B, the optical path difference between the reference light and the mark 42 outside the mark 41 then becomes equal to a product of the illumination wavelength  $\lambda$  plus  $\lambda/4$ , corresponding to a dark interference condition. As a  
20           result, the intensity of the interference image of the mark 42 outside the mark 41 becomes lowest. On the other hand, as regards the alignment mark 41, since the surface level difference is  $\lambda/4$ , the intensity becomes highest, to the contrary. As a result, a  
25           pattern (second image) such as shown in Figure 3B is produced.

          By taking a difference between these two

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same as an objective is not used. To the contrary, an intermediate image is produced at the mirror 23, and reflection light therefrom is used as a reference light. If there is any TIS described above, such as spherical aberration or comma aberration, in an optical system between an objective and a relay, which are not a common optical system, an interference image produced is shifted by one color such that a sharp interference image is not obtainable.

In the present invention, on the other hand, since it is a requisition to remove a TIS, as described, in a bright-field system, a clear or sharp interference image can be produced even where a reference light from an intermediate image is used.

As regards the relationship between the incoherence-transformation and the interference image, it has been confirmed by experiments that an interference fringe obtainable at the CCD camera 14 can be observed without speckle. This is because of that an interference fringe is produced by interference between surfaces (mirror 23 and wafer 1) which are optically conjugate with each other, that an interference fringe is produced under an interference condition established with optical path lengths between points and points upon the optically conjugate surfaces, and that the averaging is accomplished by moving the speckle relative to the fringe through the

rotary diffusion plate 32.

Figure 7 is a schematic view of a main portion of a second embodiment of the present invention. In Figure 7, like numerals as those of Figure 2 are assigned to corresponding elements.

In this embodiment, there are three lasers having different emission wavelengths. As illustrated, the system comprises a rotary diffusion plate 32, a fiber 7, an illumination system 8, a polarization beam splitter 9, a quarter waveplate 10, a first objective 11, a second objective 13, a CCD camera 14, a quarter waveplate 21, another quarter waveplate 22, a mirror 23, and a shutter 24.

In this embodiment, even if the surface level difference of a mark 2 or 3 to be detected is changed, an appropriate laser may be selected to assure production of a signal of high contrast. If, for example, the surface level difference of the mark 2 or 3 is equal to a product of the illumination wavelength by an integer plus a half wavelength, the interference image is under the same interference condition as of the alignment mark 3 or of the mark 2 outside the mark 3. Thus, the signal contrast is very low.

As a numerical example, it is assumed that the wavelength of the illumination light is 633 nm, and the surface level difference is 950 nm which corresponds to one and a half of the wavelength. This

is just the condition described above. If, for example, a laser having an emission wavelength 785 nm is used as illumination light, the level difference of 950 nm now corresponds to  $1.21\lambda$  ( $950 = 785 + 165 = 785 + 0.21 \times 785$ ), such that an interference image of high contrast can be produced.

The number of lasers to be prepared is not limited to three, as in the Figure 7 example. Only two lasers will provide a sufficient result. However, in consideration of complexity in semiconductor processes, many light sources as much as possible may preferably be used. Thus, three lasers are used in this example.

While the present invention has been described with reference to examples where a low image contrast for a small surface level difference in a bright-field detection system is increased significantly, the invention is not limited to it. For example, the invention can be applied to measurement of a mark with a three-dimensional shape, with similar advantageous results.

As shown in Figure 2, both of a He-Ne laser 31 and a halogen lamp 5 may be prepared as light source means, which may be used interchangeably. When the He-Ne laser 31 is used as a light source, measurement of a three-dimensional shape can be performed on the basis of images at four focuses

(images obtainable while changing the focus amount successively, each by a unit  $\lambda/4$ ), that is, measurement can be done in accordance with what is called a fringe scan method.

5           If, on the other hand, the halogen lamp 5 is used, there occurs white interference and thus the coherence length becomes short. Therefore, measurement of a three-dimensional shape on the basis of what is called a coherence probe method.

10           As regards details of the fringe scan method for measurement of a three-dimensional shape, reference may be made to "Needs and Seeds of Optical Measurement", Corona Co., page 228. Also, as regards details of the coherence probe method, reference may  
15           be made to "Theory and Practice of Laser Microscopes", page 82, Volume 1 of "New Optical Microscopes", Gakusai-Kikaku Co.

            Next, an embodiment of a semiconductor device manufacturing method which uses a position detecting  
20           system such as described above, will be explained.

            Figure 8 is a flow chart of procedure for manufacture of microdevices such as semiconductor chips (e.g. ICs or LSIs), liquid crystal panels or CCDs, for example.

25           Step 1 is a design process for designing a circuit of a semiconductor device. Step 2 is a process for making a mask on the basis of the circuit

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pattern design. Step 3 is a process for preparing a wafer by using a material such as silicon. Step 4 is a wafer process (called a pre-process) wherein, by using the so prepared mask and wafer, circuits are practically formed on the wafer through lithography. Step 5 subsequent to this is an assembling step (called a post-process) wherein the wafer having been processed by step 4 is formed into semiconductor chips. This step includes an assembling (dicing and bonding) process and a packaging (chip sealing) process. Step 6 is an inspection step wherein operation check, durability check and so on for the semiconductor devices provided by step 5, are carried out. With these processes, semiconductor devices are completed and they are shipped (step 7).

Figure 9 is a flow chart showing details of the wafer process.

Step 11 is an oxidation process for oxidizing the surface of a wafer. Step 12 is a CVD process for forming an insulating film on the wafer surface. Step 13 is an electrode forming process for forming electrodes upon the wafer by vapor deposition. Step 14 is an ion implanting process for implanting ions to the wafer. Step 15 is a resist process for applying a resist (photosensitive material) to the wafer. Step 16 is an exposure process for printing, by exposure, the circuit pattern of the mask on the wafer through

an exposure apparatus such as described above. The exposure process is performed after a wafer alignment process based on detection of the position of an alignment mark or marks, through a position detecting system described hereinbefore.

Step 17 is a developing process for developing the exposed wafer. Step 18 is an etching process for removing portions other than the developed resist image. Step 19 is a resist separation process for separating the resist material remaining on the wafer after being subjected to the etching process. By repeating these processes, circuit patterns are superposedly formed on the wafer.

With these processes, high density microdevices can be manufactured.

In accordance with the embodiments of the present invention as described hereinbefore, like with a phase difference detecting system, the contrast can be improved while a TIS causal factor is suppressed low, and thus a mark for position detection can be detected stably and with a good precision even in a process of a small surface level difference such as a CMP process. Therefore, the invention can provide a position detecting system and/or an exposure apparatus having the same with which a pattern of a reticle can be transferred onto the surface of a wafer very accurately and precisely.

Further, in accordance with the present invention, an interference microscope system can be used with bright-field illumination, by which a high contrast can be assured for a mark of small surface level difference such as in a CMP process. Thus, high precision position detection can be accomplished.

While the invention has been described with reference to the structures disclosed herein, it is not confined to the details set forth and this application is intended to cover such modifications or changes as may come within the purposes of the improvements or the scope of the following claims.

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WHAT IS CLAIMED IS:

1. A position detecting system, comprising:  
light source means for providing coherent  
light;  
5 incoherence-transforming means for  
transforming the coherent light from said light source  
means, into incoherent light;  
an optical system for dividing the incoherent  
light from said incoherence-transforming means,  
10 wherein one of divided light beams is directed to  
illuminate a target upon a surface of an object while  
another of divided light beams is directed to be  
reflected by a surface which is optically conjugate  
with the surface of the object, and wherein light from  
15 the target and light reflected by the conjugate  
surface are re-combined;  
image pickup means for producing an imagewise  
signal corresponding to the target on the basis of the  
light re-combined by said optical system, wherein  
20 positional information related to a position of the  
target with respect to a direction along the surface  
of the object can be produced on the basis of the  
imagewise signal; and  
image contrast adjusting means for adjusting  
25 image contrast of an image of a portion close to the  
target, as picked up by said image pickup means.

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5. A position detecting system according to Claim 4, wherein said image pickup means produces two imagewise signals related to the mark, at two positions corresponding to a peak where the difference in reflection factor at the top and bottom of the surface level difference of the mark is large and where a sign of the difference in reflection factor is inverted, and wherein the positional information related to the mark can be produced on the basis of the a difference between the two imagewise signals.

6. A position detecting system according to Claim 1, wherein said light source means includes a plurality of light sources providing different wavelengths, wherein the target comprises a mark provided on the object, wherein the mark has a surface having a surface level difference with respect to a direction of an optical axis of said optical system, wherein said image contrast adjusting means is operable to move the object along the optical axis direction of said optical system, and wherein one of said plural light sources that provides light with which a difference in reflection factor between top and bottom of the surface level difference of the mark becomes largest as the object is moved in the optical axis direction, is selectively used.

7. An exposure apparatus, comprising:

position detecting means for detecting a position of an alignment mark on a surface of a workpiece to be exposed, said position detecting means including (i) light source means for providing coherent light, (ii) incoherence-transforming means for transforming the coherent light from said light source means, into incoherent light, (iii) an optical system for dividing the incoherent light from said incoherence-transforming means, wherein one of divided light beams is directed to illuminate the alignment mark on the surface of the workpiece while another of divided light beams is directed to be reflected by a surface which is optically conjugate with the surface of the workpiece, and wherein light from the alignment mark and light reflected by the conjugate surface are re-combined, (iv) image pickup means for producing an imagewise signal corresponding to the alignment mark on the basis of the light re-combined by said optical system, and (v) image contrast adjusting means for adjusting image contrast of an image of a portion close to the alignment mark, as picked up by said image pickup means; and

exposure means for aligning the workpiece by use of positional information related to a position of the alignment mark with respect to a direction along the surface of the workpiece and produced on the basis

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of the imagewise signal, and for performing a pattern exposure to the workpiece.

8. A device manufacturing method, comprising:

5 a position detecting step for detecting a  
position of an alignment mark on a surface of a  
workpiece to be exposed, by use of a position  
detecting system which includes (i) light source means  
for providing coherent light, (ii) incoherence-  
10 transforming means for transforming the coherent light  
from the light source means, into incoherent light,  
(iii) an optical system for dividing the incoherent  
light from the incoherence-transforming means, wherein  
one of divided light beams is directed to illuminate  
15 the alignment mark on the surface of the workpiece  
while another of divided light beams is directed to be  
reflected by a surface which is optically conjugate  
with the surface of the workpiece, and wherein light  
from the alignment mark and light reflected by the  
20 conjugate surface are re-combined, (iv) image pickup  
means for producing an imagewise signal corresponding  
to the alignment mark on the basis of the light re-  
combined by the optical system, and (v) image contrast  
adjusting means for adjusting image contrast of an  
25 image of a portion close to the alignment mark, as  
picked up by the image pickup means;

a pattern exposure step for aligning the



workpiece by use of positional information related to a position of the alignment mark with respect to a direction along the surface of the workpiece and produced on the basis of the imagewise signal, and for performing a pattern exposure to the workpiece; and a development step for developing the workpiece having been exposed through said pattern exposure step, whereby a device can be produced from the developed workpiece.

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9. A device manufacturing method, comprising:  
a pattern exposure step for aligning a workpiece to be exposed and then performing a pattern exposure to the workpiece, by use of an exposure apparatus which includes (i) light source means for providing coherent light, (ii) incoherence-transforming means for transforming the coherent light from the light source means, into incoherent light, (iii) an optical system for dividing the incoherent light from the incoherence-transforming means, wherein one of divided light beams is directed to illuminate an alignment mark on a surface of the workpiece while another of divided light beams is directed to be reflected by a surface which is optically conjugate with the surface of the workpiece, and wherein light from the alignment mark and light reflected by the conjugate surface are re-combined, (iv) image pickup
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- 20
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means for producing an imagewise signal corresponding to the alignment mark on the basis of the light re-combined by the optical system, (v) image contrast adjusting means for adjusting image contrast of an image of a portion close to the alignment mark, as picked up by the image pickup means, and (vi) exposure means for aligning the workpiece by use of positional information related to a position of the alignment mark with respect to a direction along the surface of the workpiece and produced on the basis of the imagewise signal, and for performing a pattern exposure to the workpiece; and

a development step for developing the workpiece having been exposed through said pattern exposure step, whereby a device can be produced from the developed workpiece.

10. An inspecting system, comprising:
- position detecting means for performing position detection in relation to two marks provided on an object to be inspected, said position detecting means including (i) light source means for providing coherent light, (ii) incoherence-transforming means for transforming the coherent light from the light source means, into incoherent light, (iii) an optical system for dividing the incoherent light from the incoherence-transforming means, wherein one of divided

light beams is directed to illuminate the marks on a surface of the object while another of divided light beams is directed to be reflected by a surface which is optically conjugate with the surface of the object, and wherein light from the marks and light reflected by the conjugate surface are re-combined, (iv) image pickup means for producing an imagewise signal corresponding to the marks on the basis of the light re-combined by the optical system, and (v) image contrast adjusting means for adjusting image contrast of an image of a portion close to the marks, as picked up by the image pickup means; and

inspecting means for inspecting a precision of mark registration on the basis of positional information related to the marks and with respect to a direction along the surface of the object and produced from the imagewise signal from said image pickup means.

11. A position detecting system, comprising:  
at least one coherent light source;  
a diffusion plate disposed on at least one light path for the coherent light from said at least one coherent light source, said diffusion plate being movable during passage of the coherent light therethrough;  
an optical system for dividing the light

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passed through said diffusion plate, wherein one of divided light beams is directed to illuminate a target on a surface of an object, while another of divided light beams is directed to be reflected by a surface which is optically conjugate with the surface of the object, and wherein light from the target and light reflected by the conjugate surface are re-combined; and

an image pickup device disposed at a position where the light re-combined by said optical system is incident, for producing an imagewise signal corresponding to the target;

wherein positional information related to a position of the target with respect to a direction along the surface of the object can be produced on the basis of the imagewise signal; and

wherein said optical system has a function for adjusting an optical path difference between the object side light and the reference surface side light to thereby adjust an image contrast of an image of a portion close to the target, as picked up by said image pickup means.



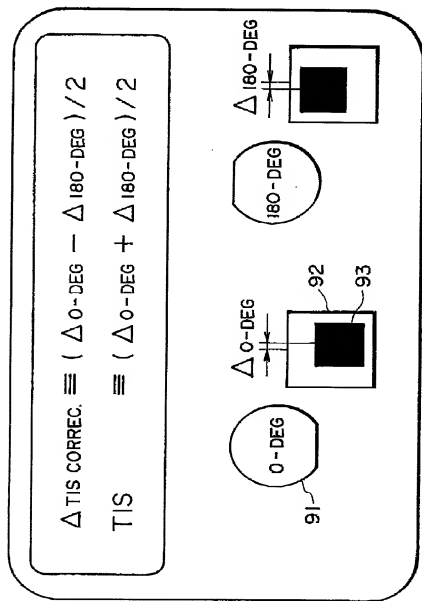


FIG. 1A

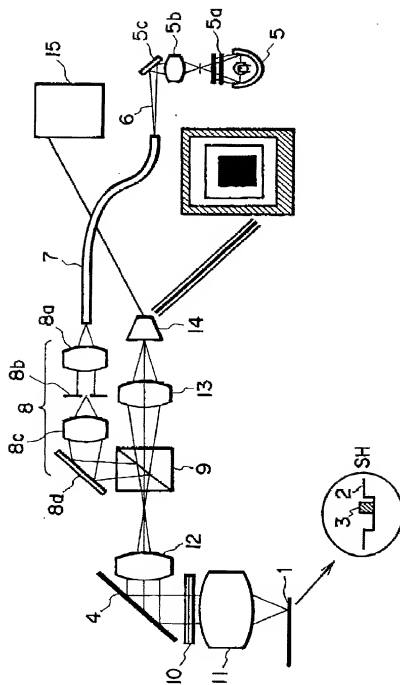


FIG. 1B

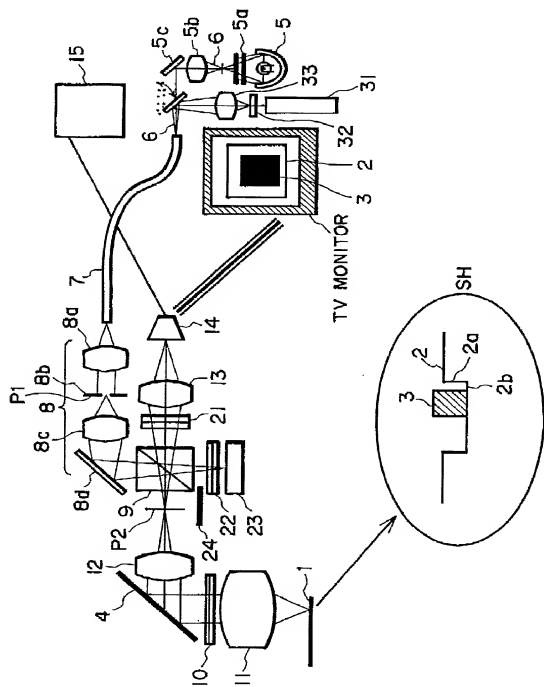


FIG. 2



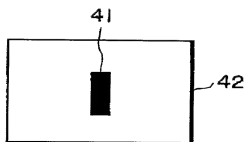


FIG. 3A

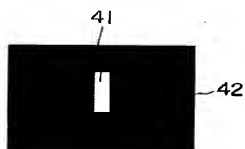


FIG. 3B

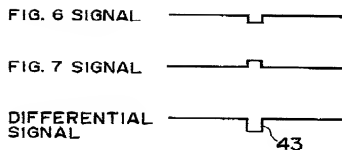


FIG. 4

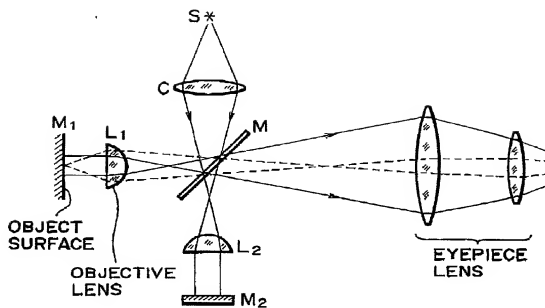


FIG. 5

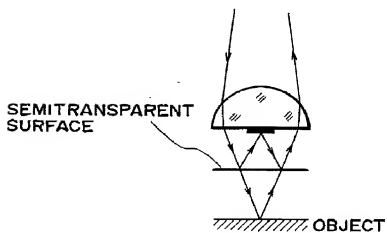


FIG. 6

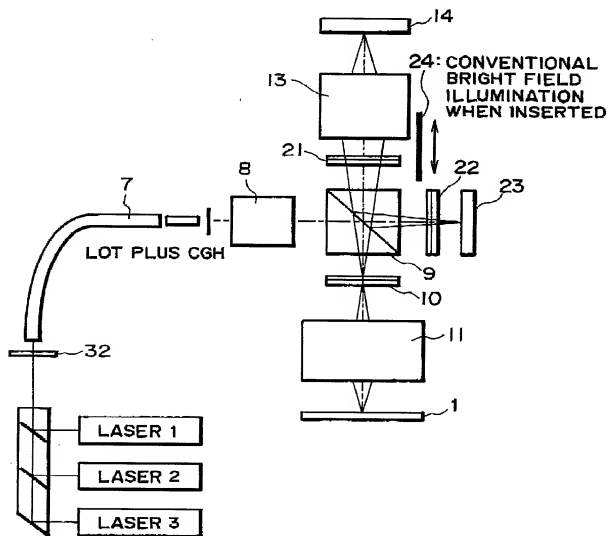


FIG. 7

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graph TD
    A[CIRCUIT DESIGN] -- "(STEP 1)" --> B[MASK MANUFACTURE]
    B -- "(STEP 2)" --> C[WAFER PROCESS  
(PRE-PROCESS)]
    D[WAFER MANUFACTURE] -- "(STEP 3)" --> C
    C -- "(STEP 4)" --> E[ASSEMBLY PROCESS  
(POST-PROCESS)]
    E -- "(STEP 5)" --> F[INSPECTION]
    F -- "(STEP 6)" --> G[SHIPMENT]
    G -- "(STEP 7)" --> H[ ]
  
```

FIG. 8

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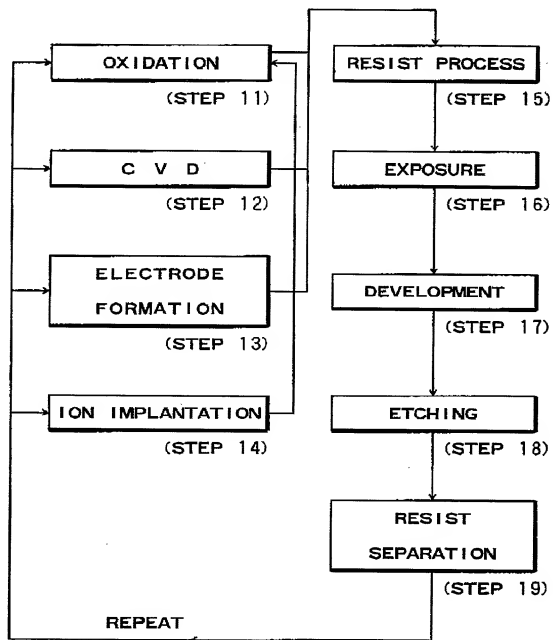


FIG. 9

COMBINED DECLARATION AND POWER OF ATTORNEY  
FOR PATENT APPLICATION  
(Page 1)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled POSITION DETECTING SYSTEM AND EXPOSURE APPARATUS USING THE SAME

the specification of which ☒ is attached hereto ☐ was filed on \_\_\_\_\_ as United States Application No. or PCT International Application No. \_\_\_\_\_ and was amended on \_\_\_\_\_ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR §1.56.

I hereby claim foreign priority benefits under 35 U.S.C. §119(a)-(d) or §365(b), of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT international application which designates at least one country other than the United States, listed below and have also identified below any foreign application for patent or inventor's certificate, or PCT international application having a filing date before that of the application on which priority is claimed:

Country	Application No.	Filed (Day/Mo./Yr.)	(Yes/No) Priority Claimed
JAPAN	10-325933	30/OCTOBER/1998	Yes

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or § 365(c) of any PCT international application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 C.F.R. § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

Application No.	Filed (Day/Mo./Yr.)	Status (Patented, Pending, Abandoned)
-----------------	---------------------	---------------------------------------

I hereby appoint the practitioners associated with the firm and Customer Number provided below to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith, and direct that all correspondence be addressed to the address associated with that Customer Number:

**FITZPATRICK, CELLA, HARPER & SCINTO**  
Customer Number: 05514

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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COMBINED DECLARATION AND POWER OF ATTORNEY  
FOR PATENT APPLICATION  
(Page 2)

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